2023 COASTAL MASTER PLAN
COMMITTED TO OUR COAST

LANDSCAPE MODELING: FINAL MODEL IMPROVEMENTS AND SCENARIO SETTINGS

ERIC WHITE

January 12, 2021

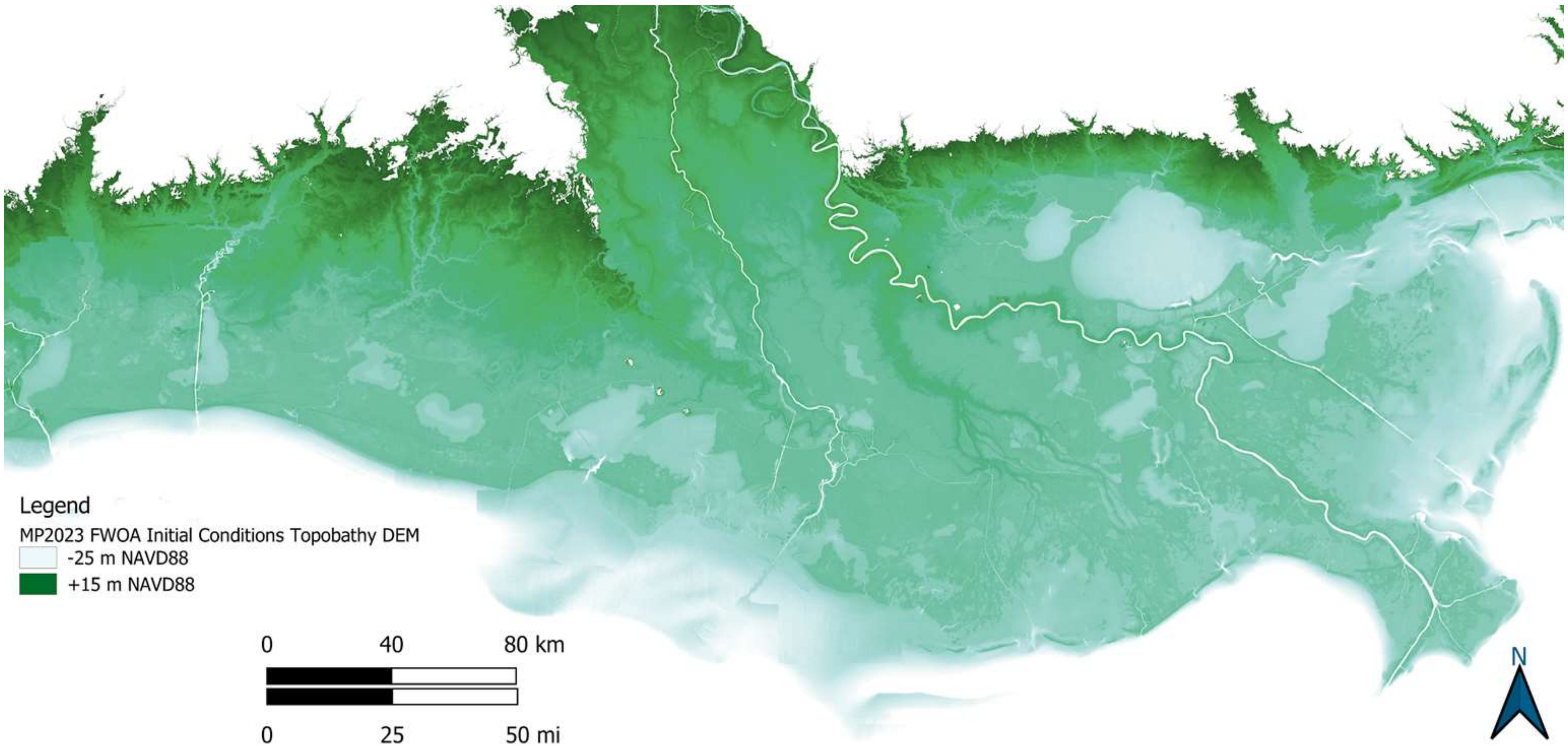
EXISTING CONDITIONS VS. INITIAL CONDITIONS

IN THE ICM

- Existing conditions:
  - The configuration of coastal Louisiana as things were on **Dec. 31, 2018**
  - Defined by collected data:
    - land/water composition
    - vegetation species coverage
    - topobathymetric elevation
    - constructed restoration and risk reduction projects
- Initial conditions:
  - The existing conditions plus any updates to the landscape to account for projects not yet built but assumed to be online for the 2023 Future Without Action (FWOA)
    - This includes projects that were recently constructed after the existing conditions data was collected
  - The initial conditions also incorporate the 2-year model spin-up period from **Jan. 1, 2019 through Dec. 31, 2020**

TOPOBATHYMETRIC DIGITAL ELEVATION MODEL (DEM)

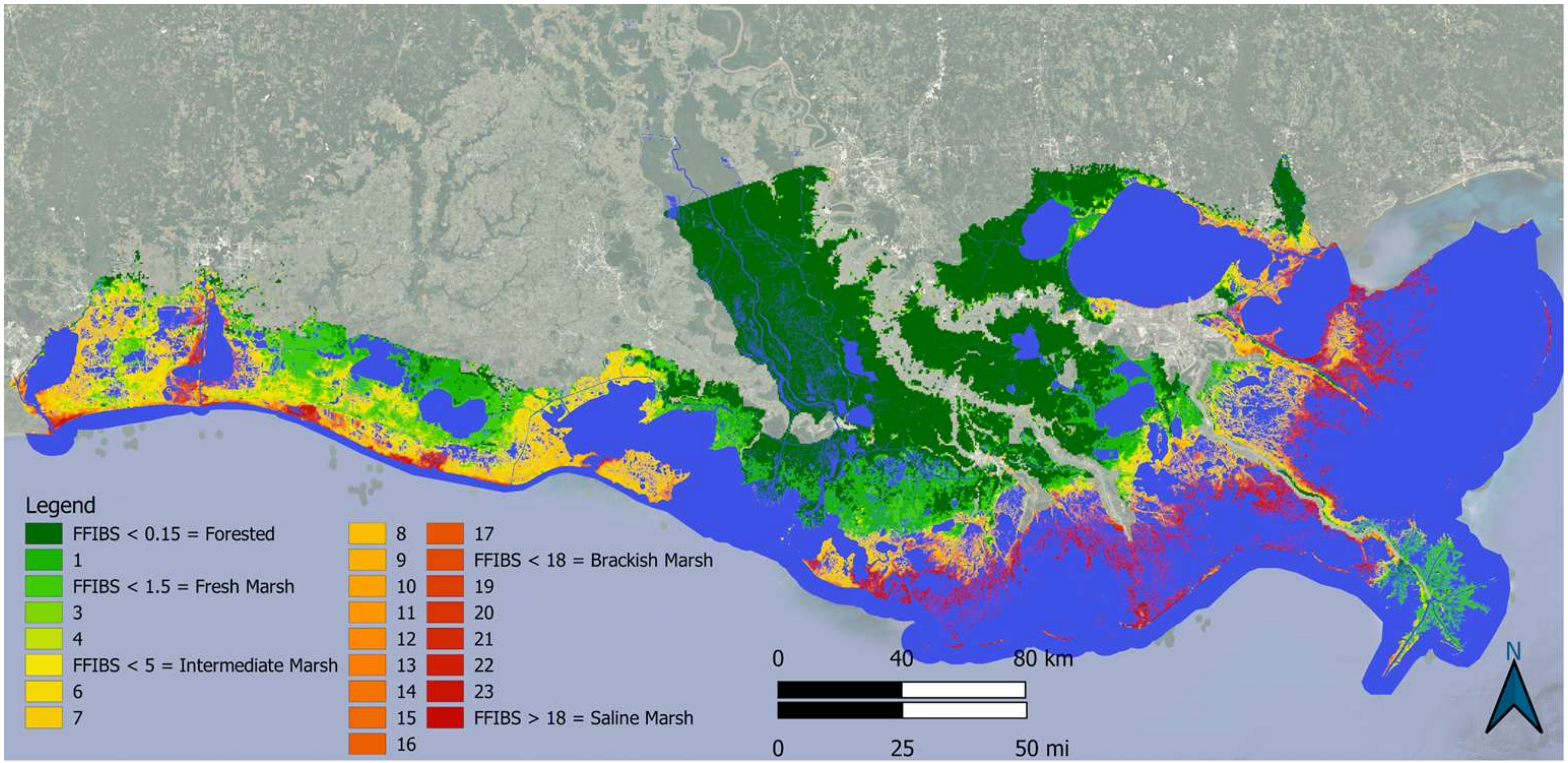
INITIAL CONDITIONS LANDSCAPE (CONSTANT ACROSS ALL SCENARIOS)



Initial condition topobathymetric DEM above uses the existing conditions (which represents the 2018 surface) DEM as a starting point. The existing conditions DEM includes the latest available topographic LiDAR and bathymetric surveys compiled by USGS (preliminary product of the USGS NGOM2 project). To represent the FWOA initial conditions, any projects that were built after LiDAR was last collected, or any projects assumed to be built during FWOA were added to the 2018 existing conditions surface.

WETLAND VEGETATION SPECIES COVERAGE

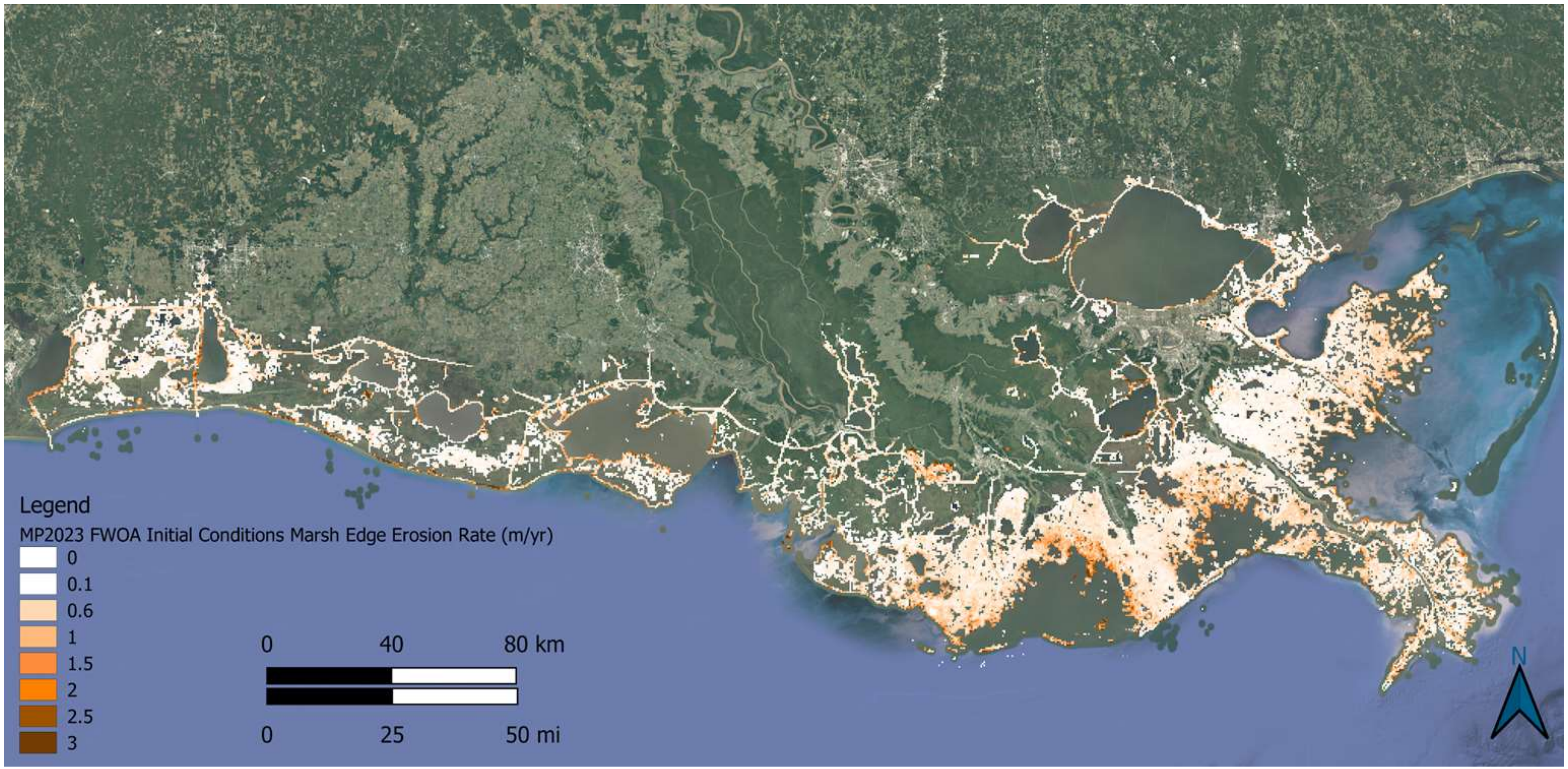
EXISTING CONDITIONS LANDSCAPE (CONSTANT ACROSS ALL SCENARIOS)



Existing conditions vegetation coverage, classified using weighted FFIBS score within each ICM-LAVegMod grid cell. Original species classifications performed on 2018 satellite imagery.

MARSH EDGE EROSION

INITIAL CONDITIONS LANDSCAPE (CONSTANT ACROSS ALL SCENARIOS)



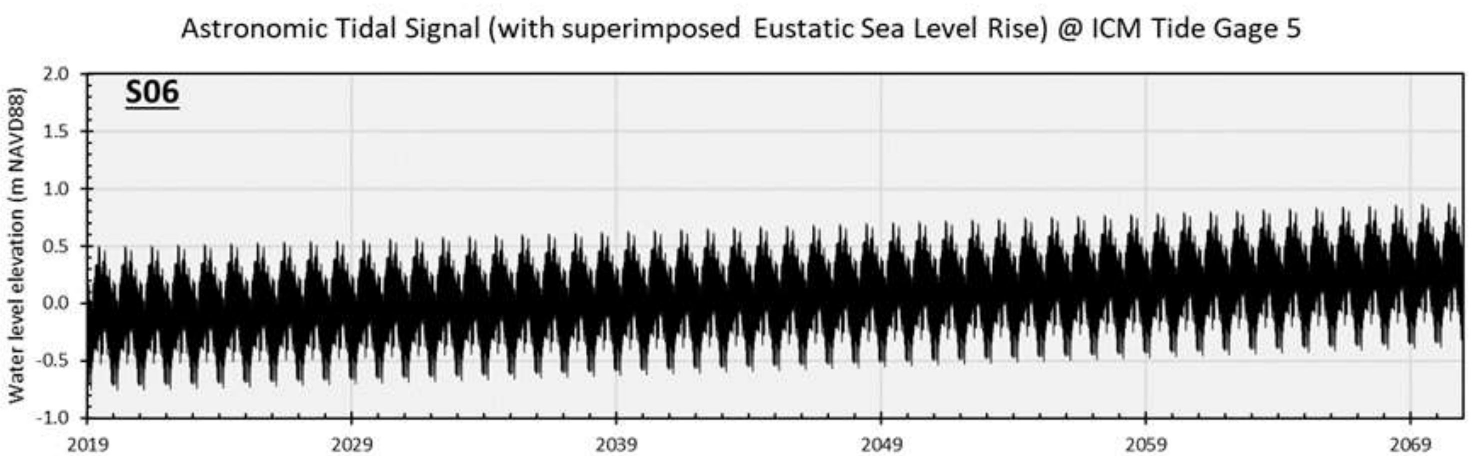
Average shoreline retreat from 2005 through 2018 - updated with FWOA projects that provide shoreline protection.

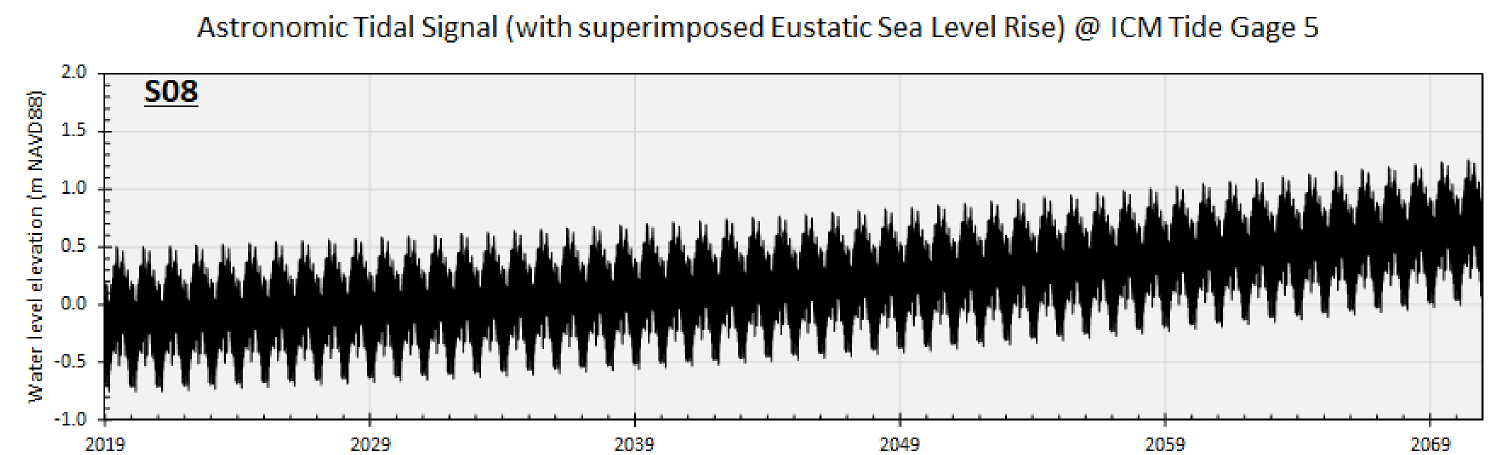

FUTURE SCENARIO
ENVIRONMENTAL FORCINGS
(TIMESERIES DATA)

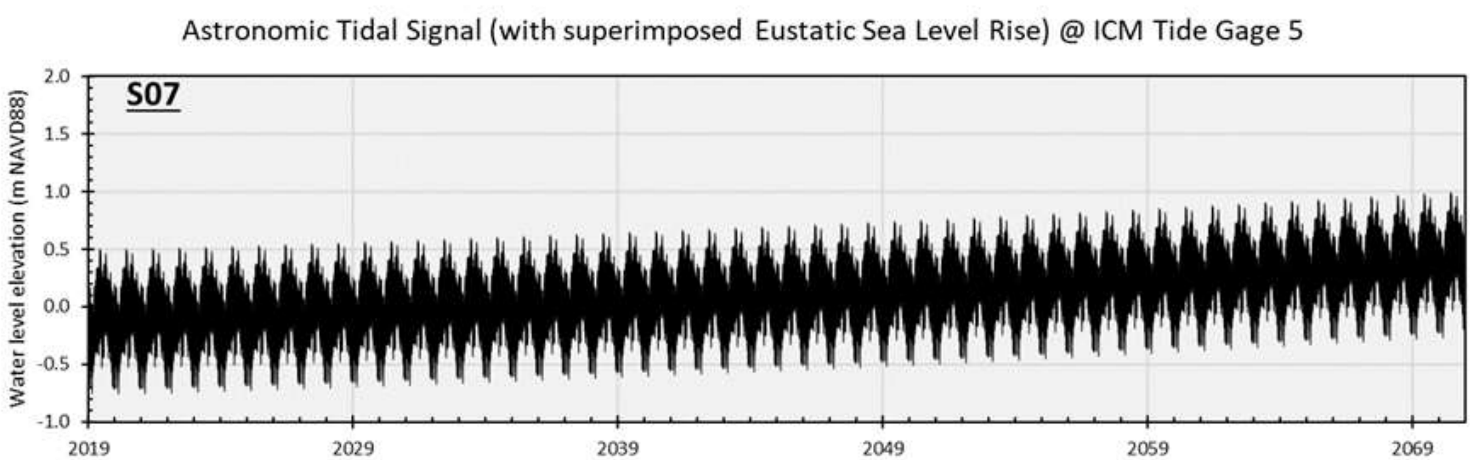
TIDAL BOUNDARY CONDITIONS

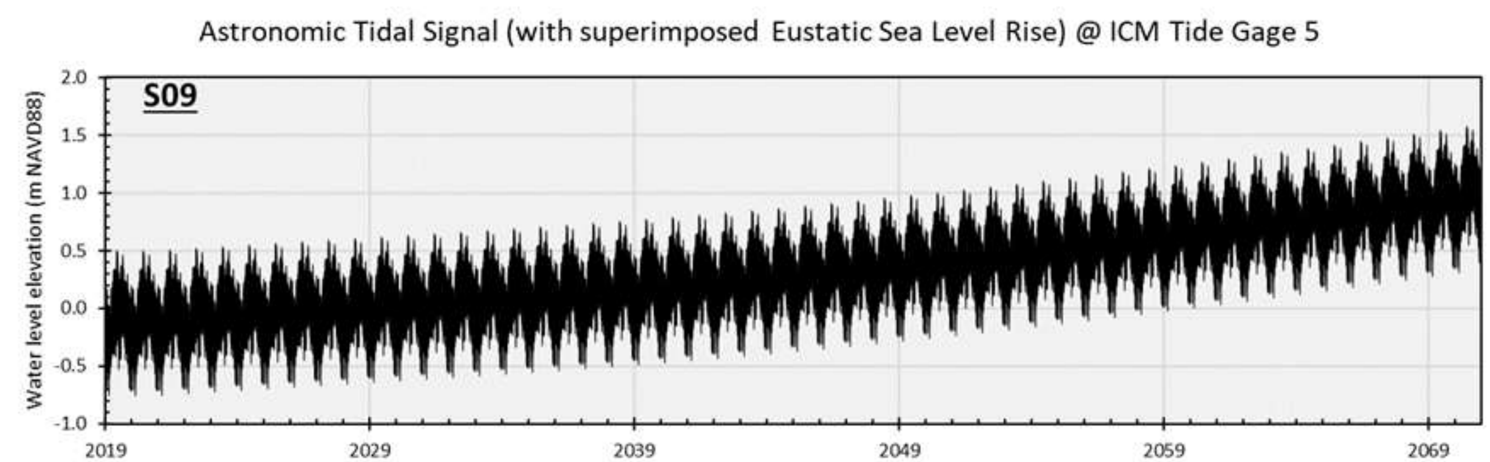
SCENARIO-SPECIFIC DATA

- Astronomic tidal + seasonal signal
- Eustatic sea level rise rates are superimposed







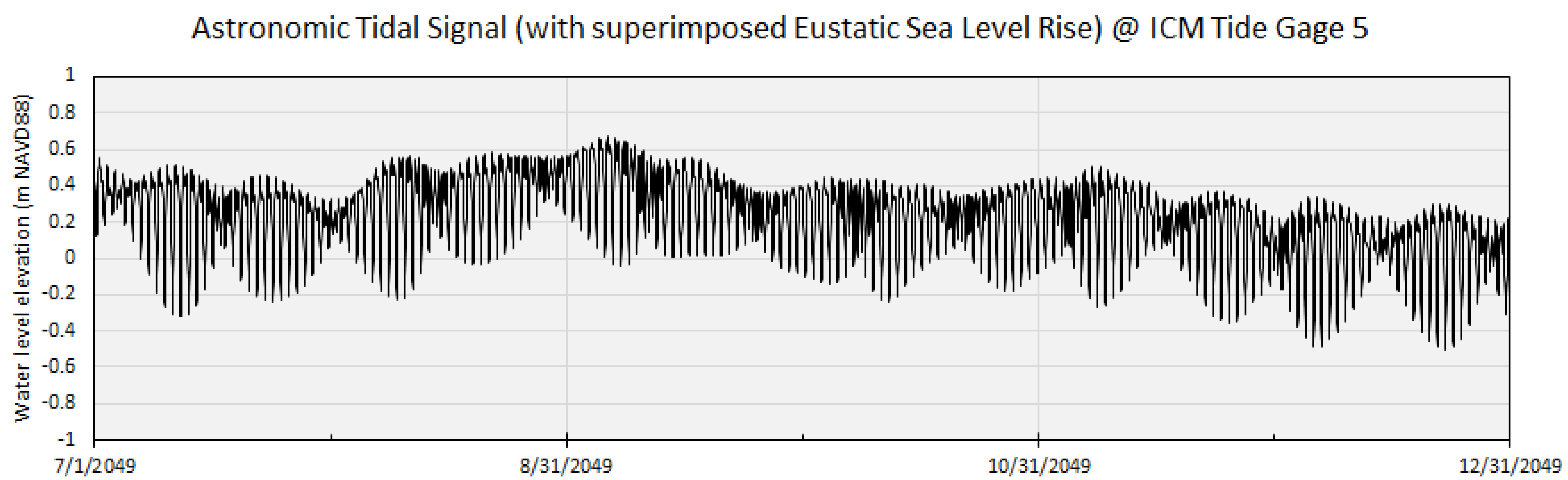


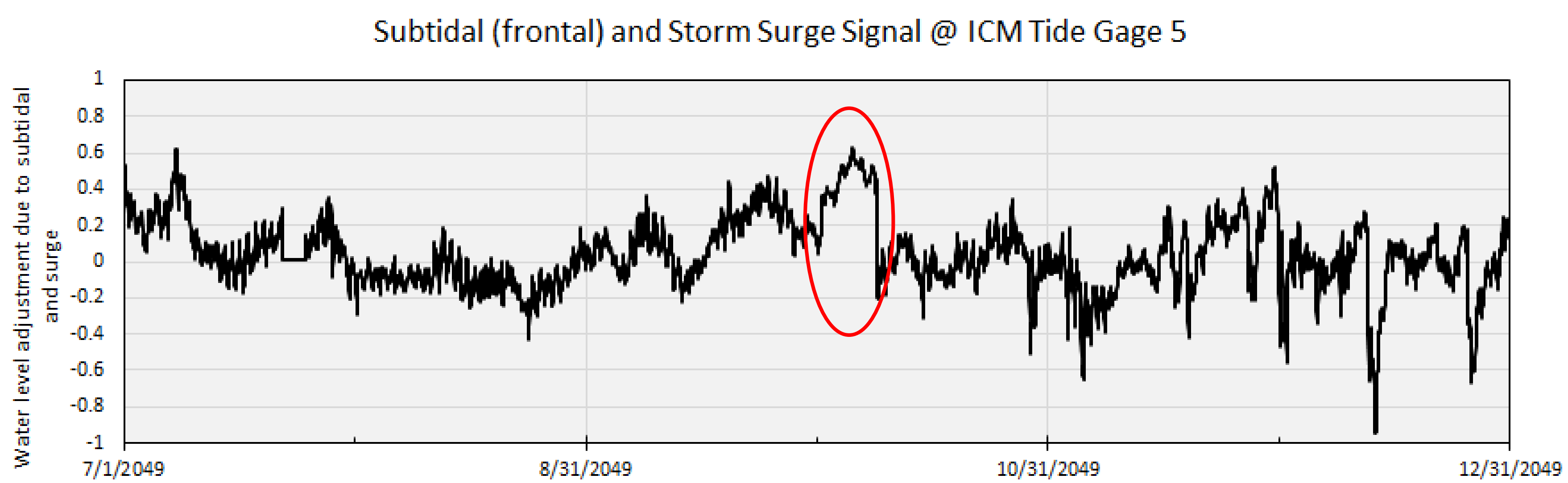
TIDAL BOUNDARY CONDITIONS

SCENARIO-SPECIFIC DATA

- Astronomic tidal + seasonal signal*
- Subtidal signal* captures frontal and other short-term deviations from astronomic tide
- When storms make landfall (red oval), the subtidal signal is adjusted

*2010 calendar year chosen as representative year due to lack of any tropical storms or hurricanes impacting coastal LA that year





BALANCED SYNTHETIC STORM SUITE

CONSTANT ACROSS ALL SCENARIOS

- New synthetic storm suite (645 storms) was analyzed to find synthetic proxies for 61 historic storms from 1970-2019
- ADCIRC-predicted water surface elevations (WSE) from each proxy storm were used to to build WSE exceedance curves across the ICM domain

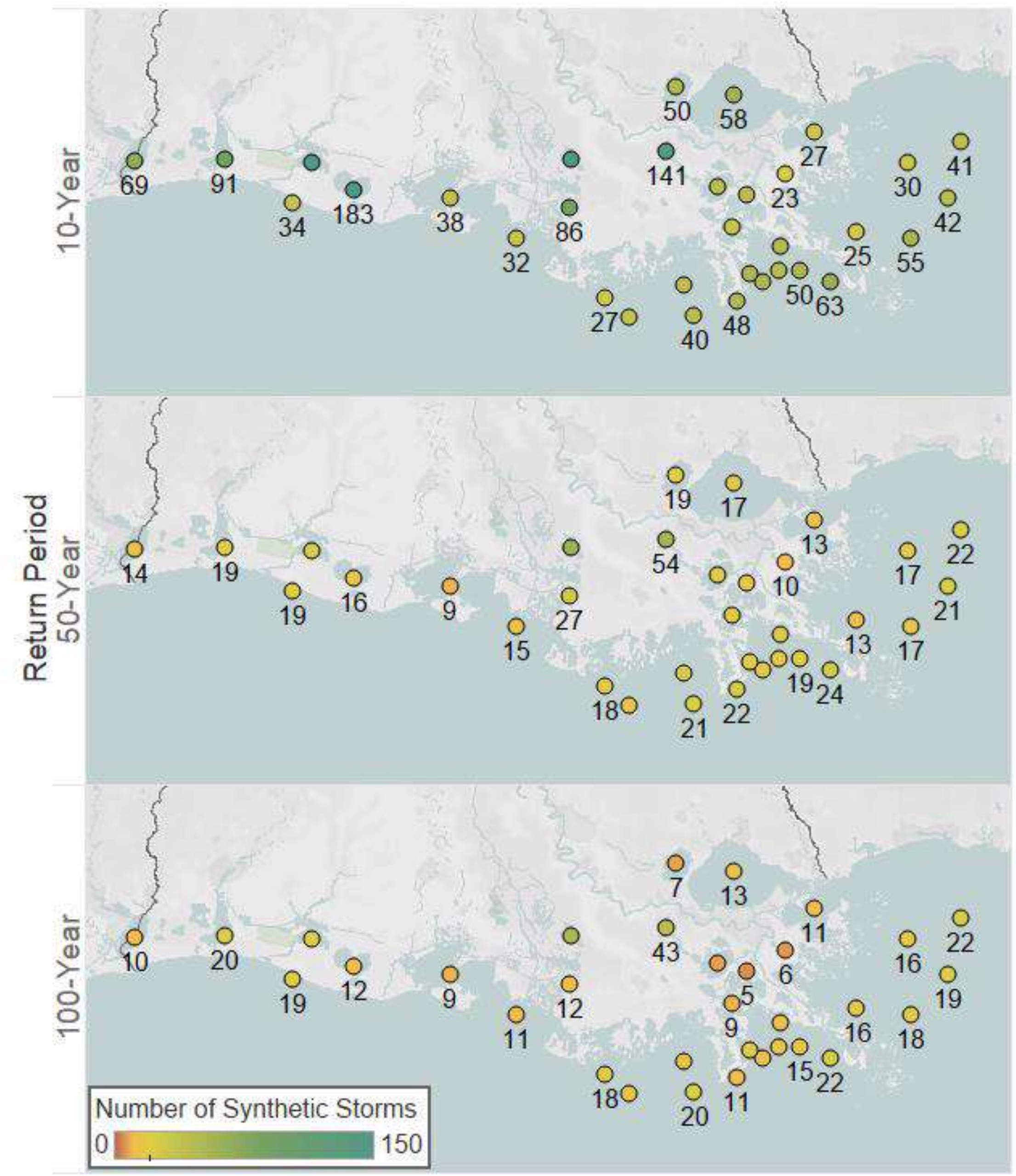
Sample locations used to develop WSE exceedance curves.

BALANCED SYNTHETIC STORM SUITE

CONSTANT ACROSS ALL SCENARIOS

- Select from the historical proxies to build a ‘balanced’ storm suite
  - ‘balanced’ = over the 50-year future scenario, each sample point should experience the same number of 5-, 10-, 50-, and 100-year WSE events

- A proxy storm was considered to match the return interval if the WSE from the proxy storm was within 0.5-ft of the calculated WSE exceedance value

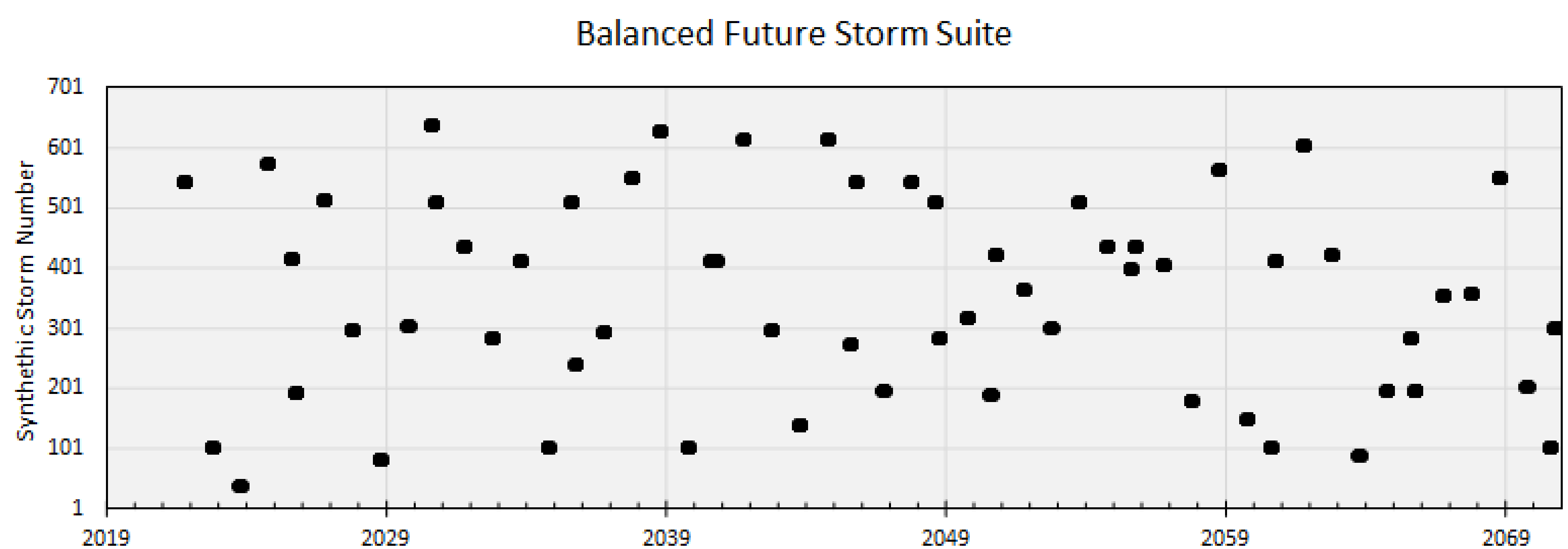


Number of synthetic storms matching WSE values with indicated return periods (0.5-foot tolerance).

BALANCED SYNTHETIC STORM SUITE

CONSTANT ACROSS ALL SCENARIOS

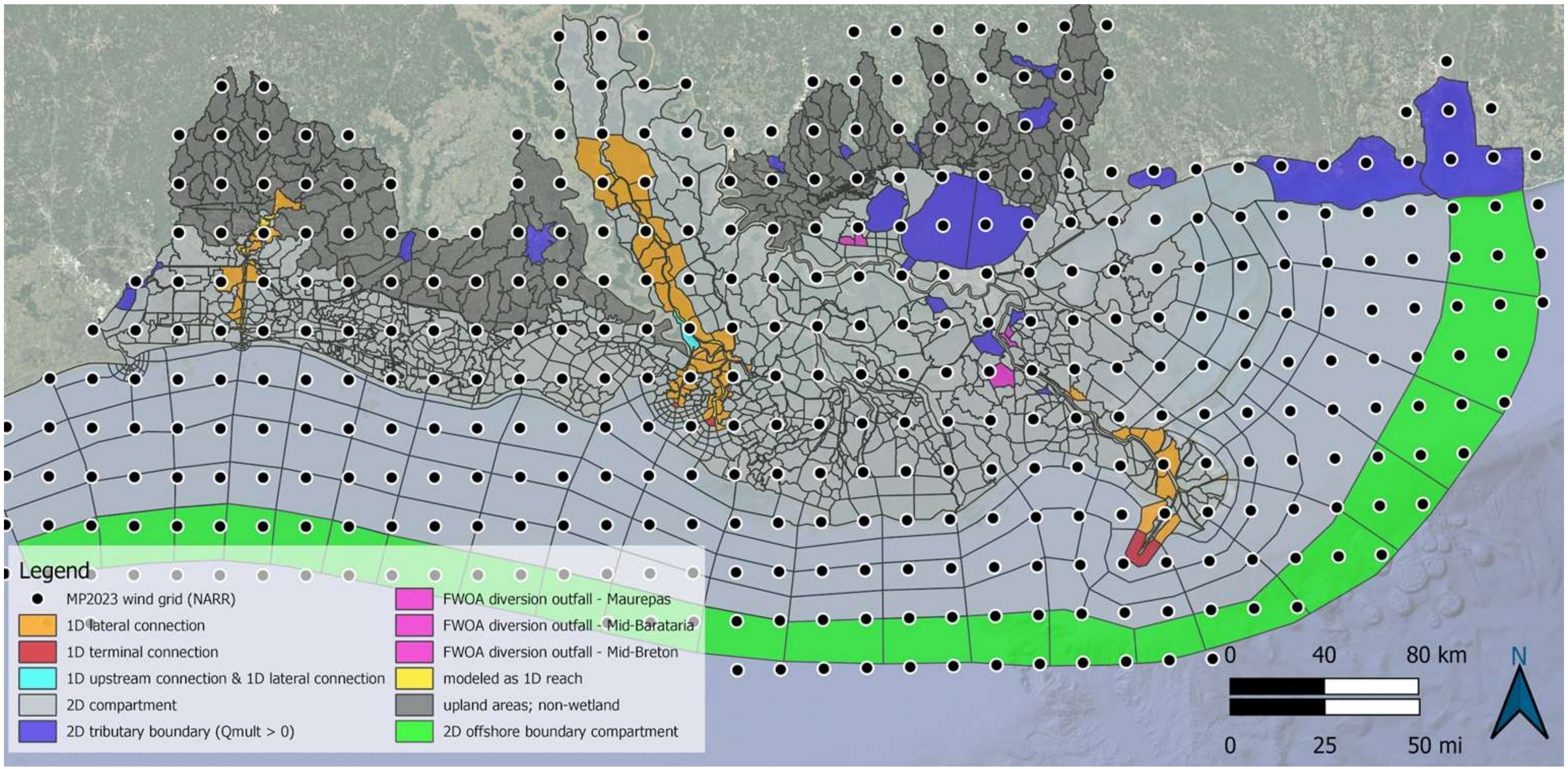
- ADCIRC-generated data from each synthetic storm in the balanced suite was provided to build ICM-Hydro boundary forcings
    - hourly water level in Gulf
    - wind speed and direction
    - precipitation (following IPET-methodology)
- Every year has a storm making landfall on Oct. 1
- Eleven years have an additional storm making landfall on Aug. 1:
    - 2025, 2030, 2035, 2040, 2045, 2048, 2050, 2055, 2060, 2065, 2070



Date and synthetic storm number of balanced future storms.

WIND BOUNDARY CONDITIONS

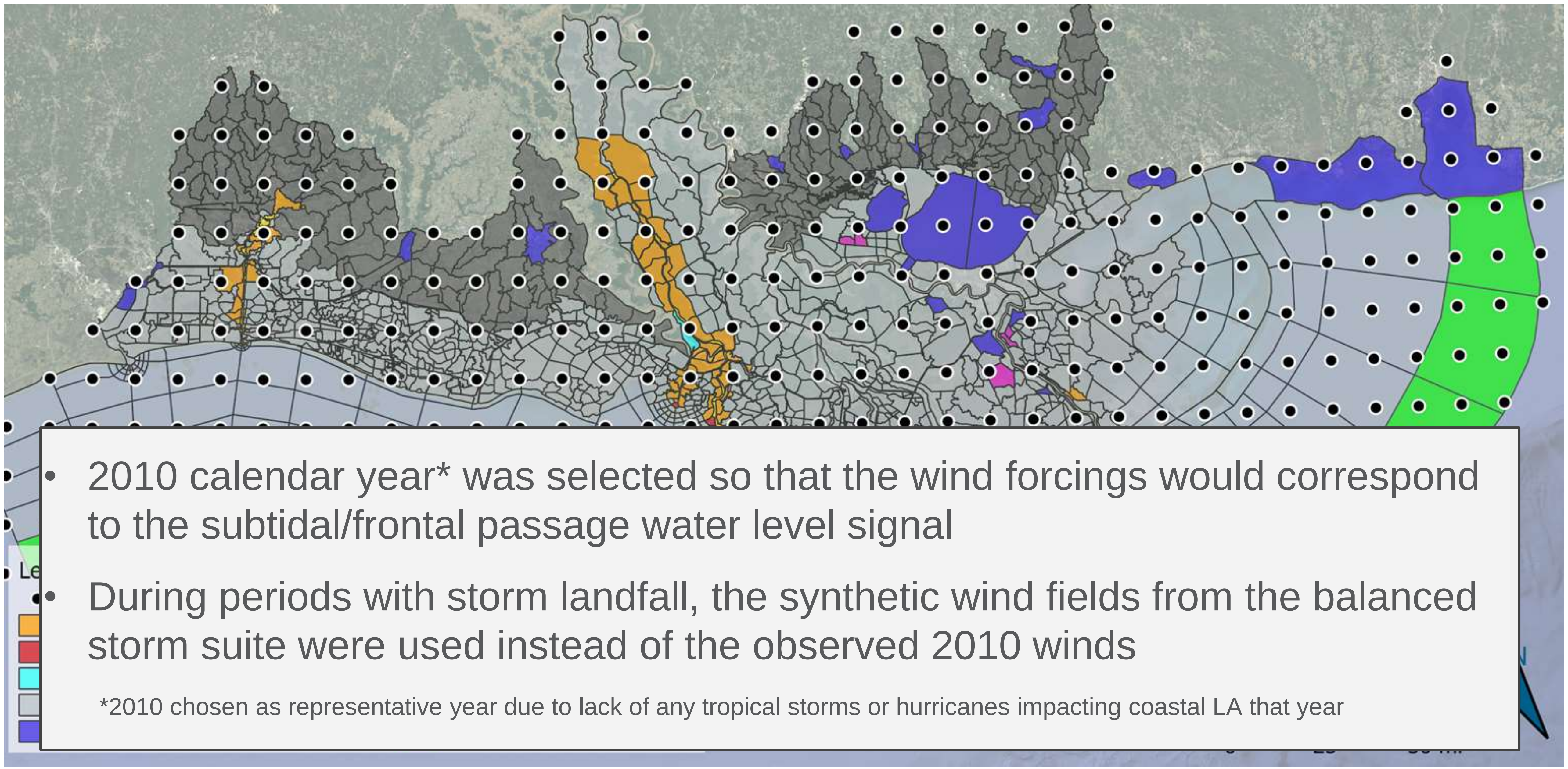
SCENARIO-SPECIFIC DATA (ONLY IF STORMS VARY ACROSS SCENARIOS)



NARR wind grid used to develop wind fields for ICM-Hydro.

WIND BOUNDARY CONDITIONS

SCENARIO-SPECIFIC DATA (ONLY IF STORMS VARY ACROSS SCENARIOS)



- 2010 calendar year* was selected so that the wind forcings would correspond to the subtidal/frontal passage water level signal
- During periods with storm landfall, the synthetic wind fields from the balanced storm suite were used instead of the observed 2010 winds

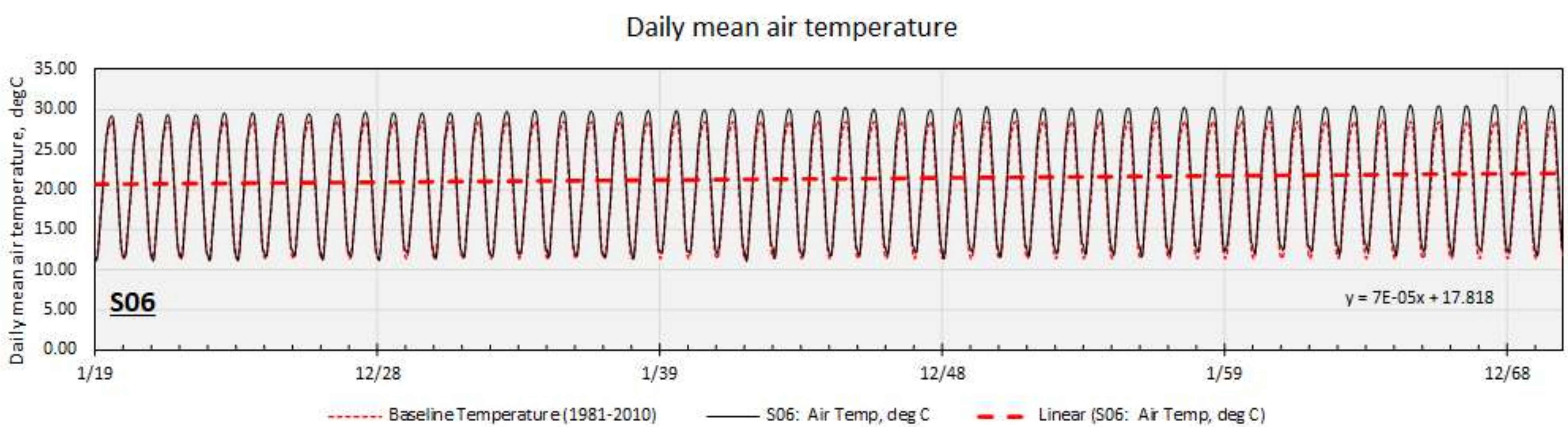
*2010 chosen as representative year due to lack of any tropical storms or hurricanes impacting coastal LA that year

NARR wind grid used to develop wind fields for ICM-Hydro.

TEMPERATURE BOUNDARY CONDITIONS

SCENARIO-SPECIFIC DATA

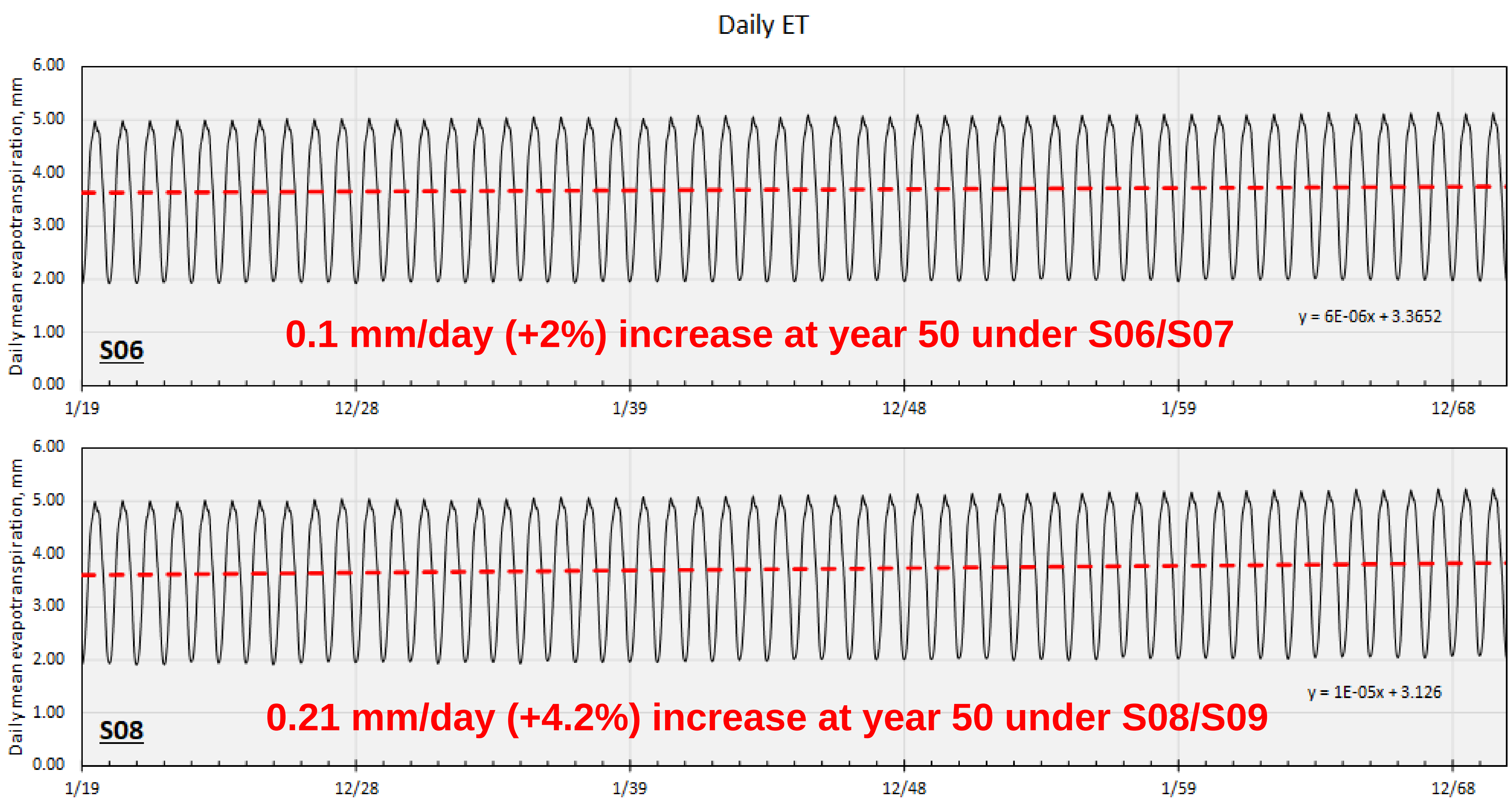
- IPCC/CMIP5 model output was used to develop temperature trends that are coupled to the assumed sea level rise scenarios
- These temperature trends were applied to 3 baseline temperatures:
  - air temperature
  - river water temperature (Mississippi River at Baton Rouge USGS data)
  - estuary water temperature (Barataria Bay near Grand Terre USGS data)



EVAPOTRANSPIRTAION BOUNDARY CONDITIONS

SCENARIO-SPECIFIC DATA

- IPCC/CMIP5 model output was used to develop temperature trends that are coupled to the assumed sea level rise scenarios
- These temperature trends were applied to the Hargreaves-Solemani ET equations

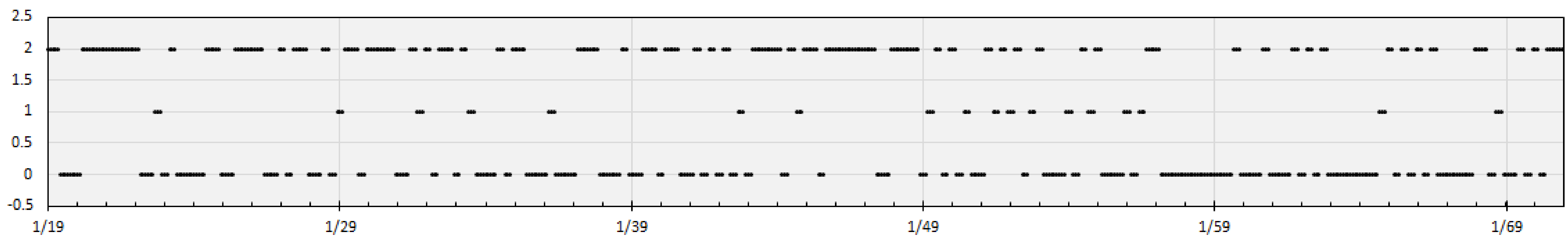


PRECIPITATION BOUNDARY CONDITIONS

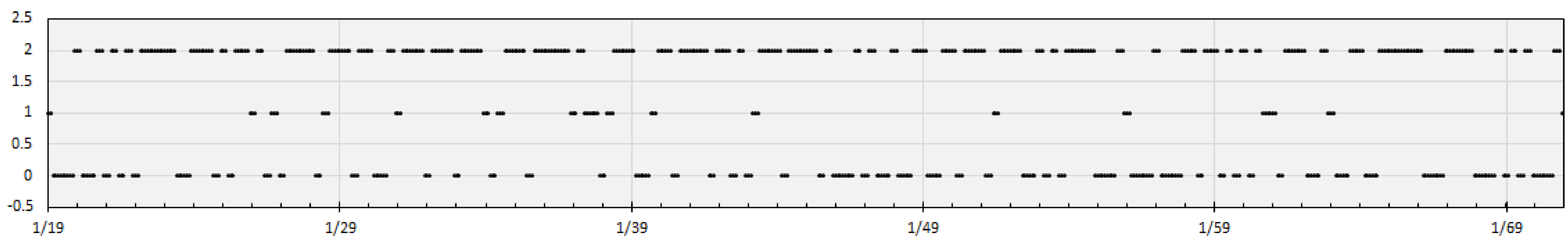
SCENARIO-SPECIFIC DATA

- Gridded radar rainfall data from 2006 through 2013 was used to select representative *wet*, *dry*, and *average* rainfall seasons (index values of 2, 0, and 1, respectively in figures below).
- IPCC/CMIP5 model output was used to develop rainfall trends that are coupled to the assumed sea level rise scenarios
- During periods with storm landfall, the synthetic rainfall fields from the balanced storm suite were used instead of the radar rainfall data

S06/S07 monthly wetness index



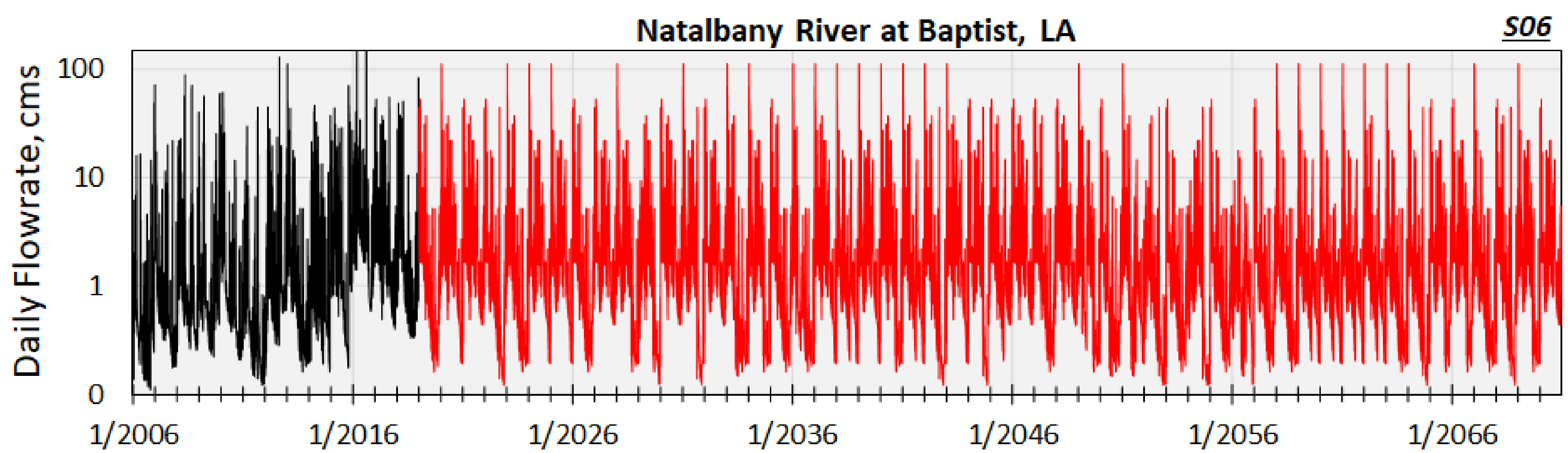
S08/S09 monthly wetness index

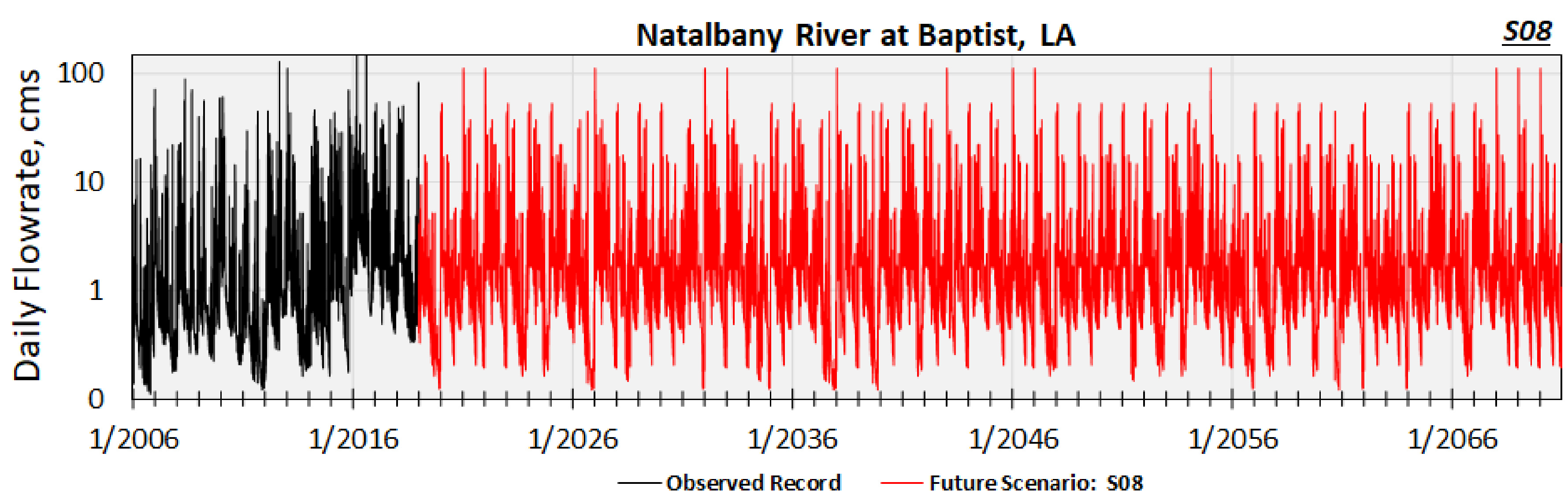


TRIBUTARY FLOW BOUNDARY CONDITIONS

SCENARIO-SPECIFIC DATA FOR ALL TRIBUTARIES OTHER THAN MISSISSIPPI AND ATCHAFALAYA RIVERS

- IPCC/CMIP5 model output was used to develop rainfall trends that are coupled to the assumed sea level rise scenarios
- Future rainfall trend is assumed to correspond directly to the same trend in coastal tributaries (e.g., if season has average rainfall, tributary flow will also be average)

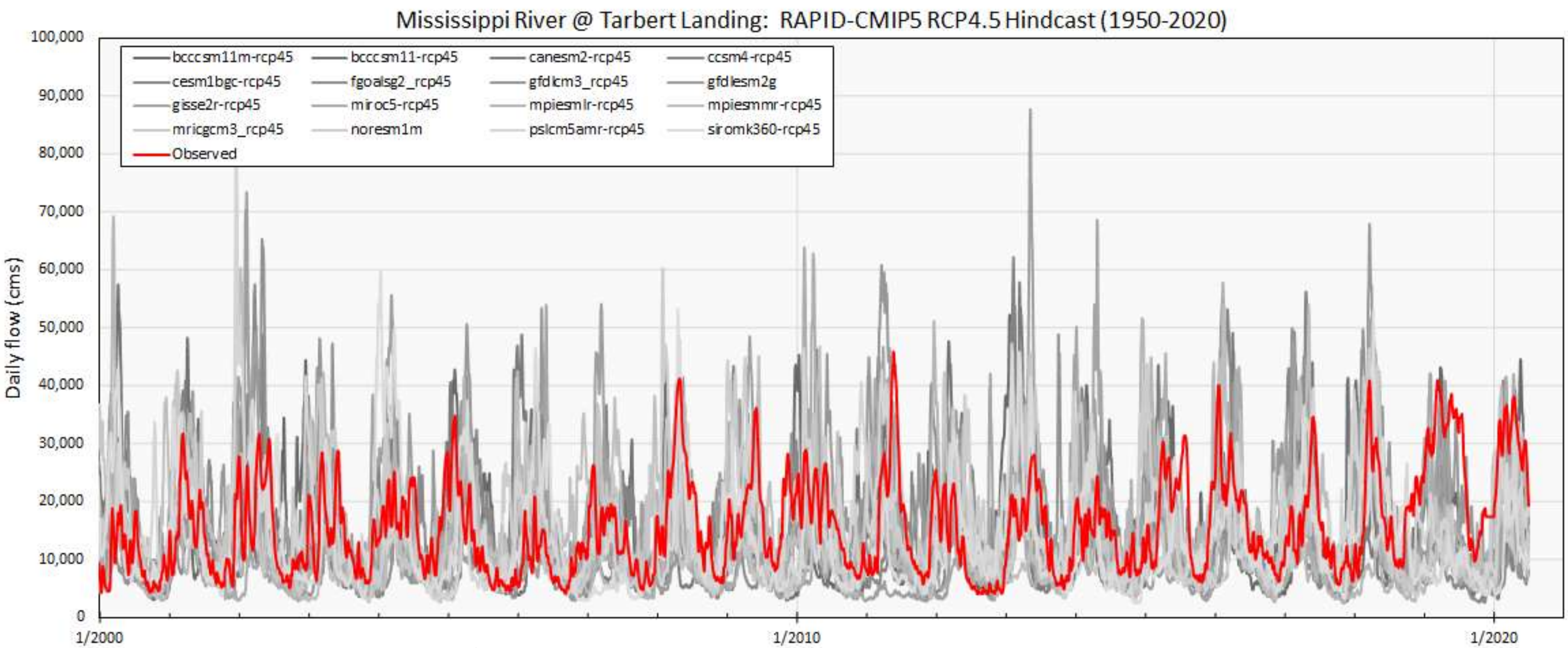




MISSISSIPPI RIVER FLOW BOUNDARY CONDITIONS

CONSTANT ACROSS ALL SCENARIOS

USACE ERDC provided daily river flows from the continental-scale RAPID H&H model from 1950 through 2100 from a 16-member ensemble using IPCC RCP-4.5 daily precipitation forcing.

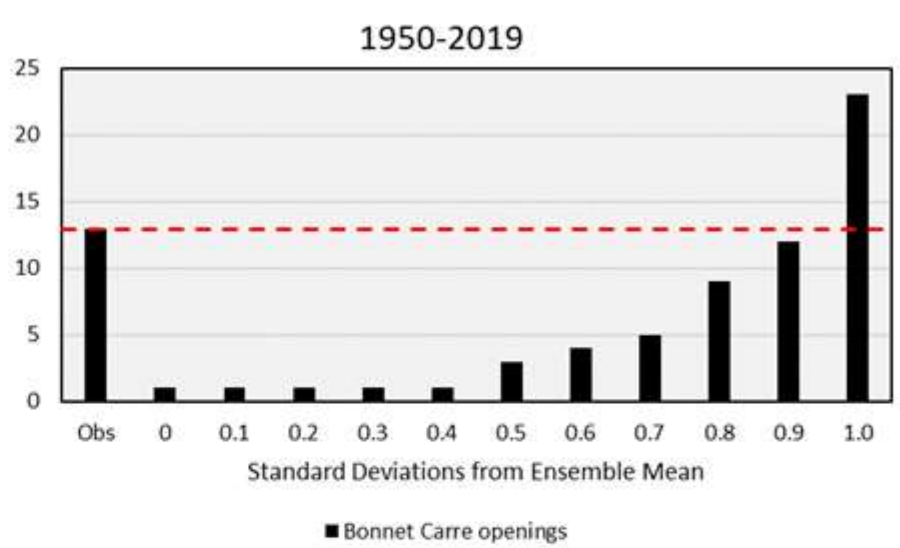


Hindcast ensemble members compared to the observed flow at Tarbert Landing, 2000 through 2020.

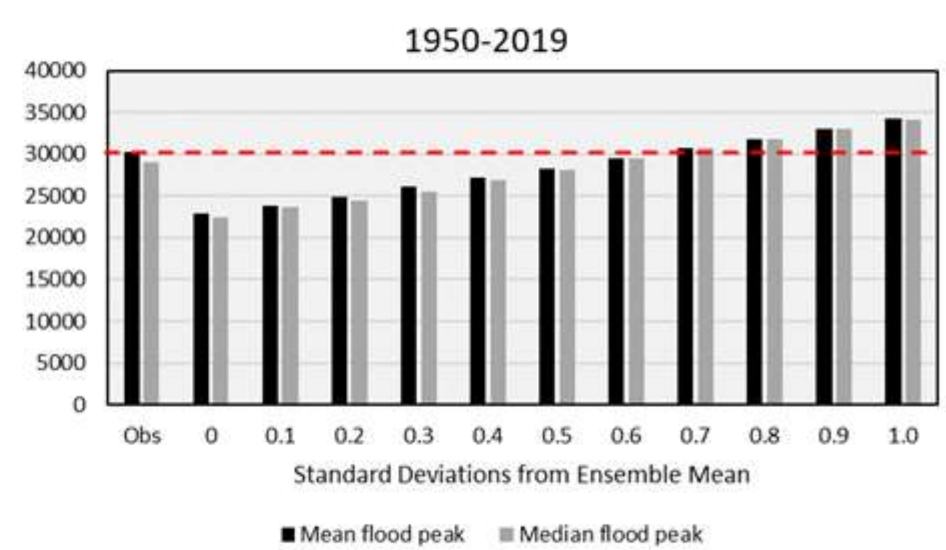
MISSISSIPPI RIVER FLOW BOUNDARY CONDITIONS

CONSTANT ACROSS ALL SCENARIOS

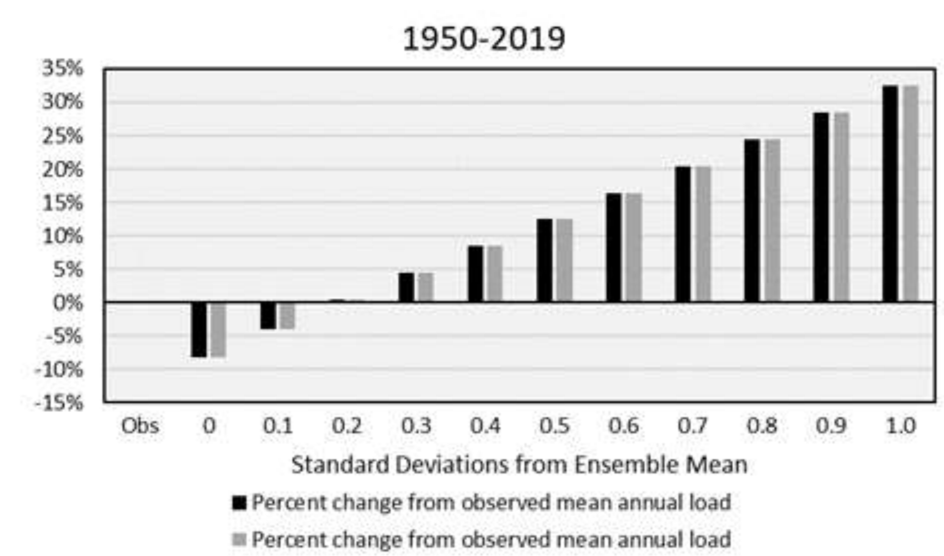
- Using a simple ensemble mean would result in a low-flow bias for all future simulations
- Examined three metrics to determine which ensemble average should be used:
  - compare number of Bonnet Carre openings in hindcast to the observed record
  - compare mean/median springtime flood peak discharge
  - compare mean total volumetric freshwater flux
- To match frequency of historic Bonnet Carre openings, the ensemble mean + 0.9 standard deviations should be used
  - this would put ~30% more freshwater, on average, into the coastal system every year
- To match annual total freshwater flux, ensemble mean + 0.2 standard deviations should be used
  - this would underpredict the mean annual flood discharge by 5k cms (~18%)
  - low bias w.r.t. Bonnet Carre opening frequency
- Using **ensemble mean + 0.6 standard deviations** matches the mean spring flood peak
  - increases mean total freshwater flux by ~15%
  - low bias w.r.t. Bonnet Carre opening frequency



Comparison of number of Bonnet Carre openings between hindcast ensemble and observed, 1950-2019.



Comparison of mean annual flood peak discharge between hindcast ensemble and observed, 1950-2019.

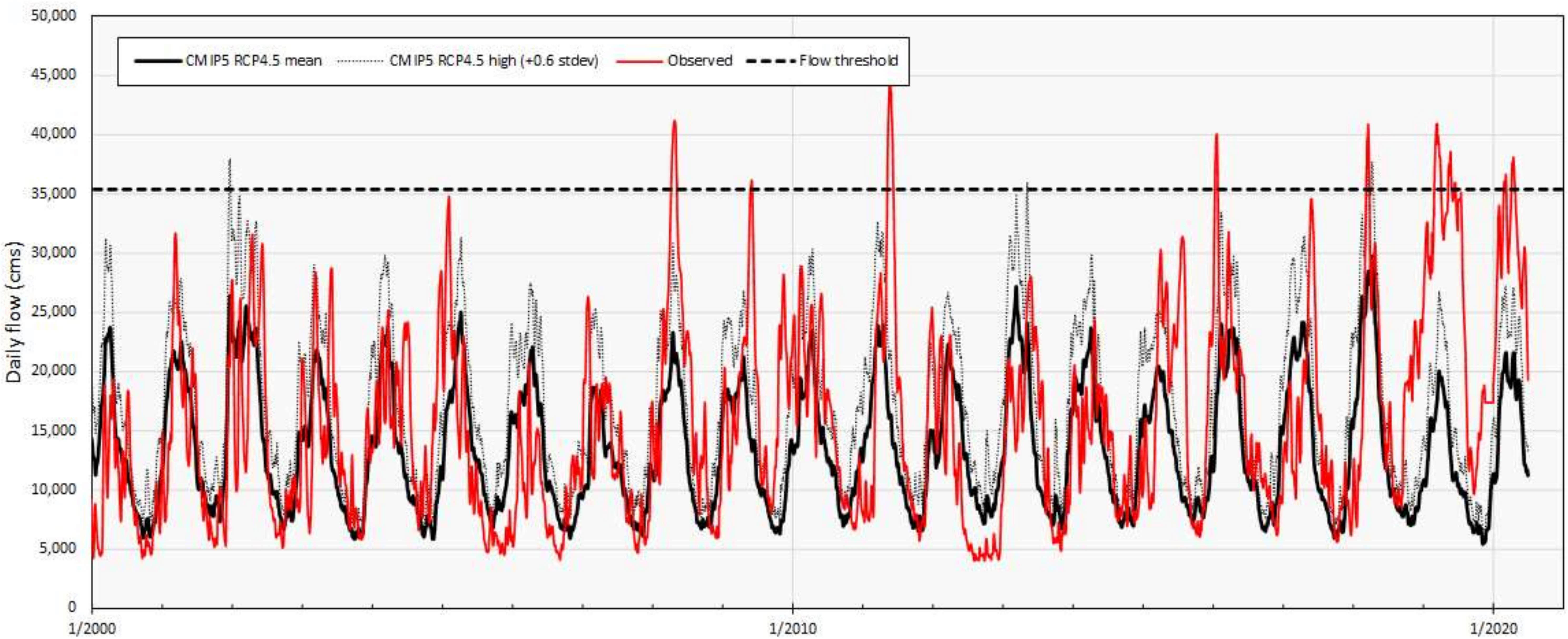


Comparison of mean annual total freshwater volumetric load between hindcast ensemble and observed, 1950-2019.

MISSISSIPPI RIVER FLOW BOUNDARY CONDITIONS

CONSTANT ACROSS ALL SCENARIOS

Below figure is the hindcast comparison of ensemble mean discharge (+0.6 st dev) to the observed discharge for the Mississippi River at Tarbert Landing.

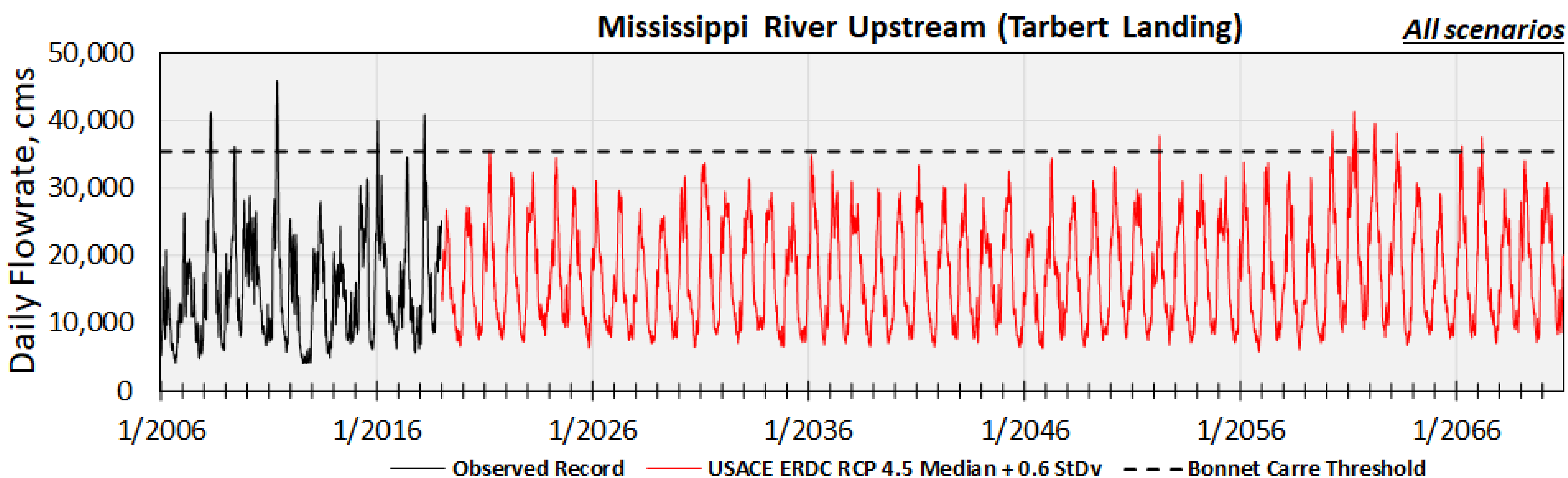


Hindcast ensemble mean and ensemble mean + 0.6 standard deviations compared to the observed flow at Tarbert Landing. Horizontal dashed line indicates flow threshold which triggers opening of the Bonnet Carre spillway.

MISSISSIPPI RIVER FLOW BOUNDARY CONDITIONS

CONSTANT ACROSS ALL SCENARIOS

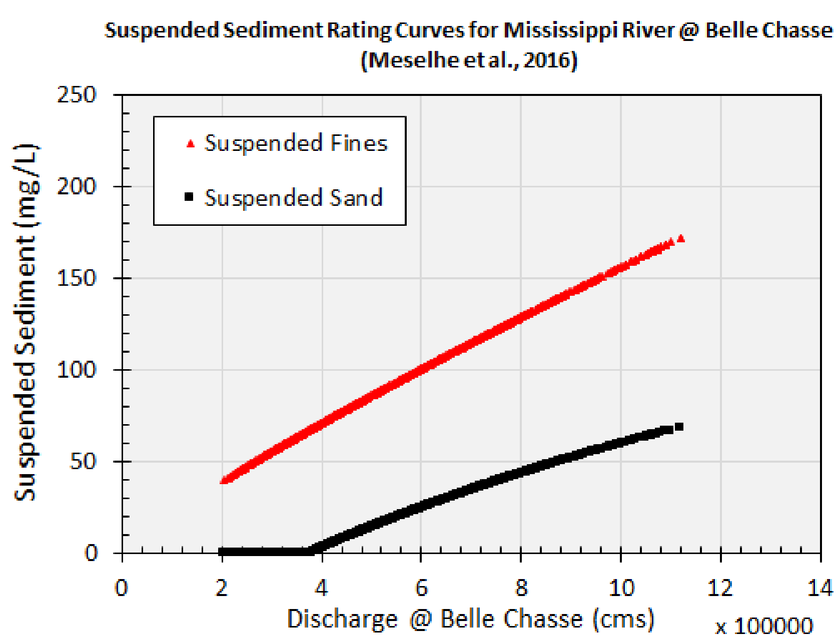
Future scenario hydrograph for Mississippi River at Tarbert Landing.



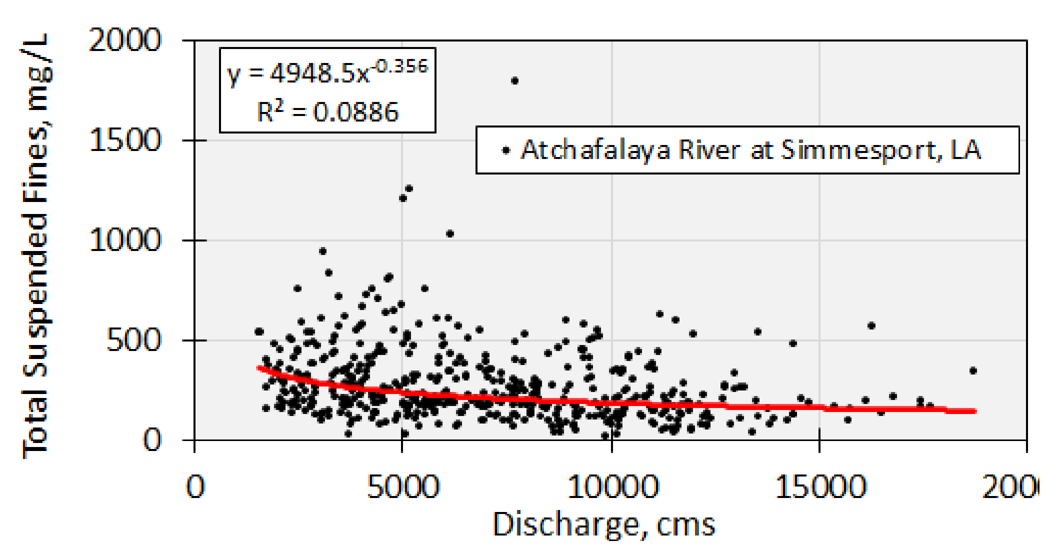
SUSPENDED SEDIMENT-DISCHARGE RATING CURVES

CONSTANT ACROSS ALL SCENARIOS

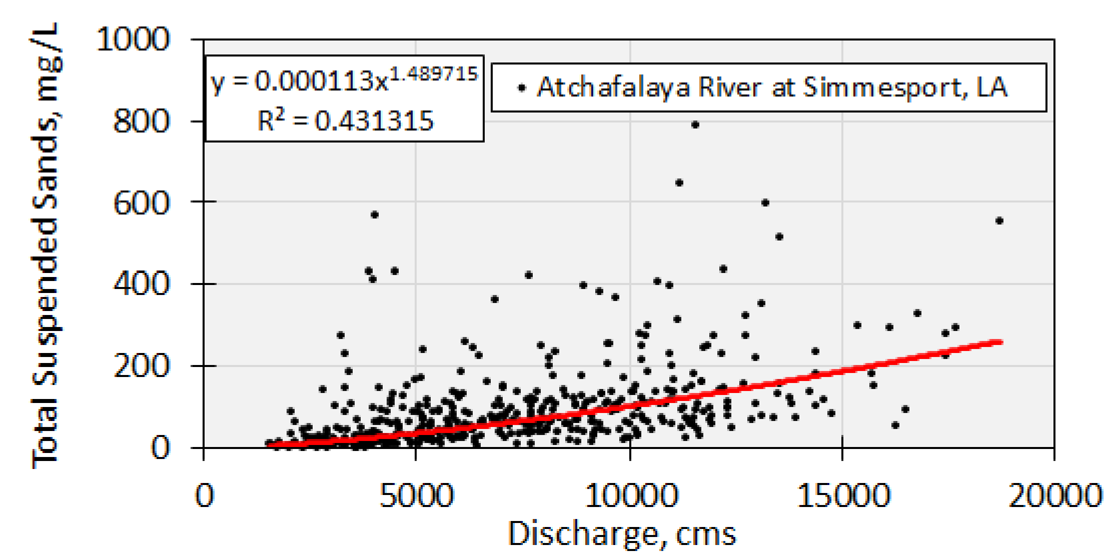
- Separate rating concentration curves for suspended fines and sands for Mississippi and Atchafalaya Rivers
- Mississippi River:
  - hysteresis-informed rating curves from Meselhe et al., (2016)
- Atchafalaya River:
  - develop curves from USGS paired sediment-Q data



Hysteresis-informed rating curves for suspended fines and suspended sand concentrations in the Mississippi River at Belle Chase (from Meselhe et al., 2016).



Suspended fine sediment **concentration** rating curve for the Atchafalaya River.

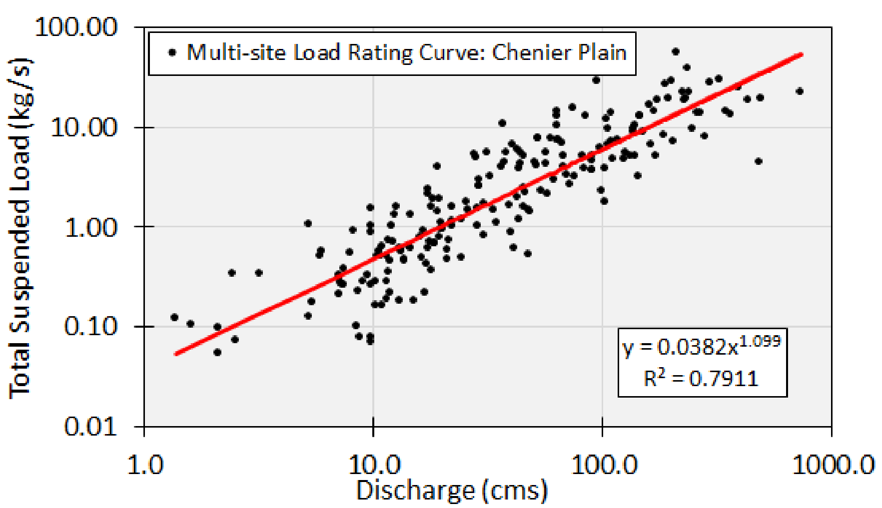


Suspended sand sediment **concentration** rating curve for the Atchafalaya River.

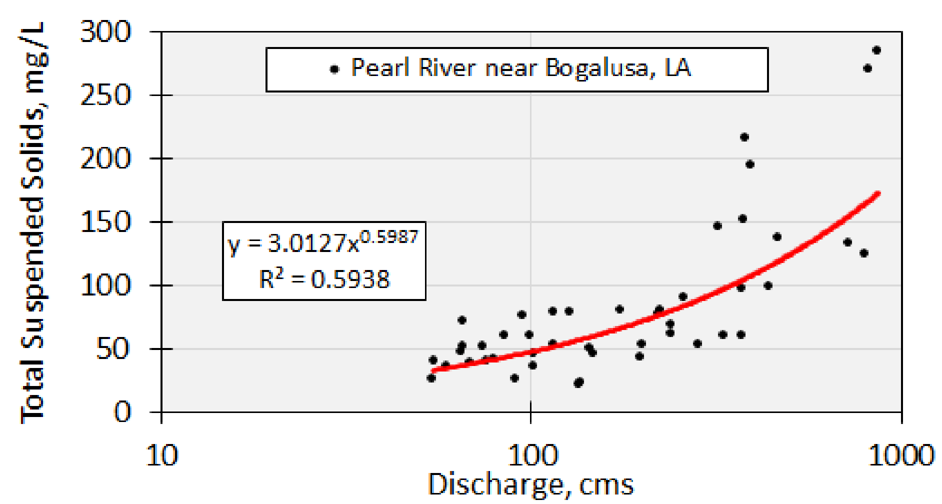
SUSPENDED SEDIMENT-DISCHARGE RATING CURVES

CONSTANT ACROSS ALL SCENARIOS

- Mississippi and Atchafalaya River have separate rating curves for suspended sand and fine concentration
- All other coastal tributaries have a rating curve for *total suspended sediments*
- West of Mississippi River (excluding Atchafalaya River):
  - limited sediment-discharge paired data
  - combine all paired data into one regional sediment **load** rating curve
- East of Mississippi River:
  - sediment **concentration** rating curve from paired sediment-discharge data for: Pearl River, Bogue Chitto, & Tangipahoa Rivers
  - discharge-area-sediment **concentration** relationships for: Tchefuncte, Tickfaw, Natalbany, and Amite Rivers (from Roblin MS Thesis, 2008)



Total suspended sediment **load** rating curve for sites west of the Mississippi River



Total suspended sediment **concentration** rating curve for the Pearl River.

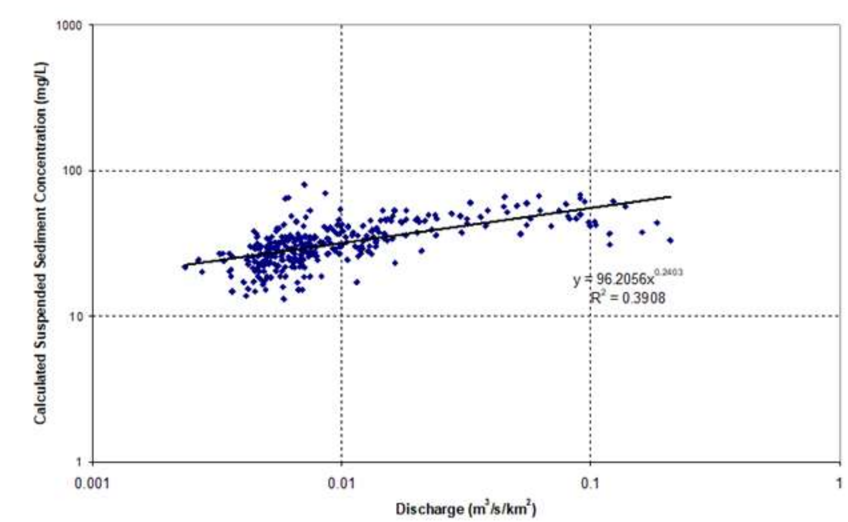


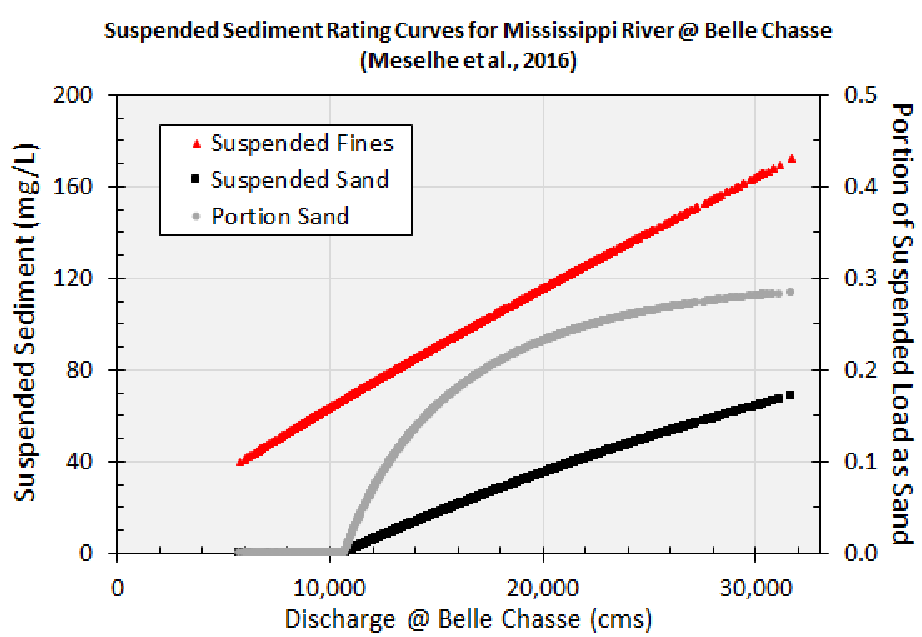
Figure A.51 Relationship between suspended sediment concentration and turbidity for the Tickfaw River.

Total suspended sediment **concentration** rating curve from drainage-area normalized discharge for the Tickfaw River (from Roblin, 2008)

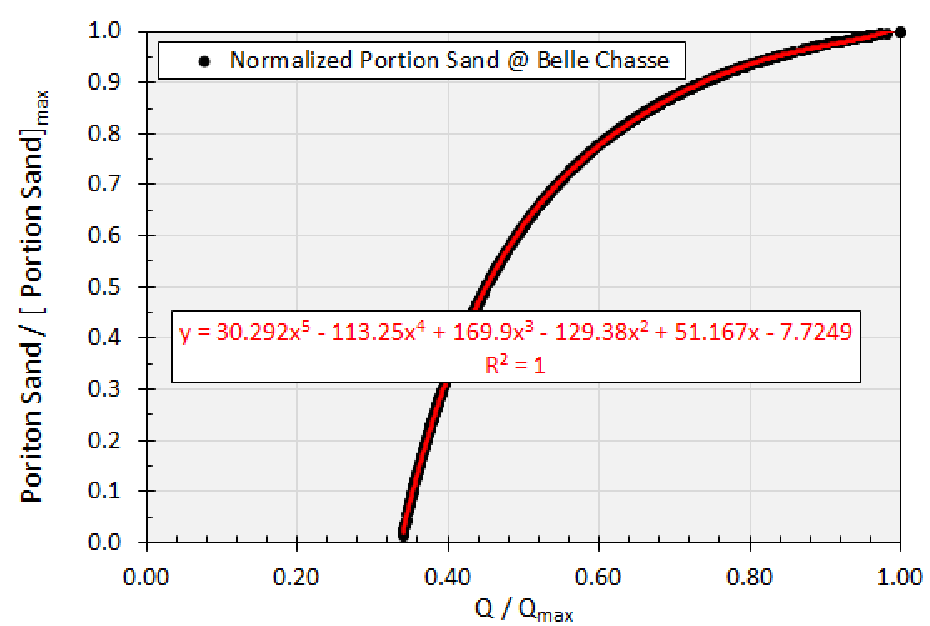
SUSPENDED SEDIMENT-DISCHARGE RATING CURVES

CONSTANT ACROSS ALL SCENARIOS

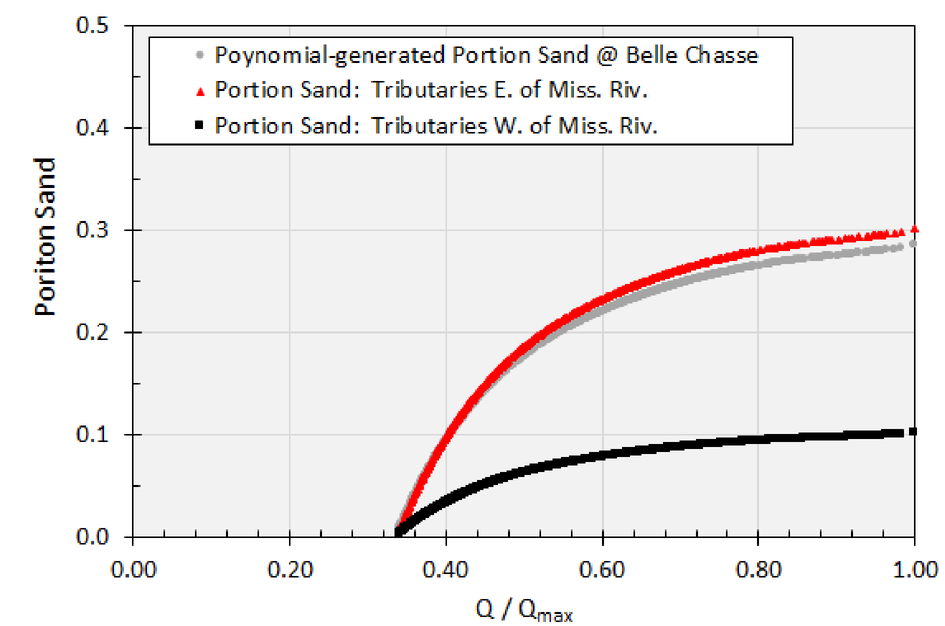
- Coastal tributaries have a rating curve for *total suspended sediments*
- Partition into sands/fines:
  - east of Mississippi River, assume max sand = 30% *TSS
  - west of Mississippi River, assume max sand = 10% *TSS
- Fines/sand suspended data at Belle Chasse used to define flowrate which initiates sand suspension (function of river's max discharge)



Fines and sand rating curves at Belle Chasse, with portion sand curve.



Portion sand curve normalized by maximum portion sand and maximum discharge; fitted polynomial shown in red.



Maximum-normalized portion sand curves for Mississippi River @ Belle Chasse (gray), coastal tributaries east of Mississippi River (red), and coastal tributaries west of Mississippi River (black).